DOCUMENT RESUME

ED 297 029 TM 012 008

AUTHOR Bezruczko, Nikolaus
TITLE Artistic Judgment: A Review of Research. Technical Report 1988-1.
INSTITUTION Johnson O'Connor Research Foundation, New York, NY. Human Engineering Lab.
REPORT NO TR-1988-1
PUB DATE Mar 88
NOTE 48p.
PUB TYPE Information Analyses (070)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Aptitude Tests; *Creativity Research; Literature Reviews; *Psychometrics; Psychophysiology
IDENTIFIERS *Artistic Evaluation; Johnson O Connor Aptitude Tests; Psychobiology

ABSTRACT

A literature review and associated recommendations for research and testing of artistic judgment (AJ) are presented. Studies of AJ aptitude testing and related research are reviewed. G. T. Fechner's psychophysical, G. P. Birkhoff's mathematical, H. J. Eysenck's factor analytic, and D. E. Berlyne's psychobiological approaches to AJ are discussed. Results concerning an association between individuals' preference judgments and their quality of AJ, and the neurological development of AJ are considered. Basic issues in the philosophy of structuralism are related to the development of AJ tests. An AJ instrument, developed by the Johnson O'Connor Research Foundation (JOCRF) and known as Proportion Appraisal, is also reviewed. Current tests of AJ are inadequate; a test constructed on the basis of information theory may be more successful. It is concluded that the JOCRF should develop and pilot test an artistic processing instrument for the foundation's battery. A seven-page list of references and a three-page bibliography are provided. (TJH)

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A REVIEW OF RESEARCH

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Technical Report 1988-1

March, 1988

TM 012008

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Artistic Judgment: A Review of Research

Nikolaus Bezruczko

Abstract

The purpose of this report is to present a literature review and recommendations for research and testing to the Johnson O'Connor Research Foundation (JOCRF) for an aptitude called artistic judgment.

The report summarizes studies of artistic judgment aptitude testing and related research. The review begins with the psychophysical studies of Gustav Fechner and is followed by Birkhoff's mathematical, Eysenck's factor analytic, and Berlyne's psychobiological approaches to artistic judgment. An artistic judgment instrument developed by JOCRF, Proportion Appraisal, is also reviewed.

The report concludes that current tests of artistic judgment are inadequate, but that a test constructed on the basis of information theory may be more successful. The report recommends that the Foundation develop and pilot an artistic processing instrument for the JOCRF battery.

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Acknowledgments

Thanks are due to the staff of the Johnson O'Connor Research Foundation. They have contributed substantially to this report.

I would like specifically to thank David Schroeder, the Research Manager for the Foundation. His reviews of drafts, recommendations for an empirical study, and factor analytic perspective materially improved the preparation of this report.

Introduction to the Study of Artistic Judgment

Purpose of Report

The primary goal of this literature review is to identify artistic judgment tests in common use and document their psychometric properties. A secondary goal is to review experimental studies that examine the underlying processes involved with artistic judgment. The conclusion of the report is an evaluation of the artistic judgment literature, leading to recommendations for research and testing.

Practical Origins

Historically the study of art was dominated by historians and philosophers. Their approach was largely spiritual, concentrating on the religious aspects of aesthetic emotional states. By the middle of the nineteenth century, however, psychologists became interested in the relationship between art and visual perception. They studied artistic judgment as a specialized form of visual perception, associated with preference judgments. This began the psychophysical approach to artistic judgment, in which stimulus characteristics were manipulated and perceptual responses were measured during laboratory experiments. The psychologists' empirical findings established the experimental study of artistic judgment that continues in contemporary research.

The nineteenth-century psychophysical interest in art focused on a theoretical understanding of artistic judgments and visual perception. The interest of the psychologists was not in aptitude testing. Not until the early twentieth century, when practical concerns regarding the evaluation of art products and educational counseling became important, did test development become emphasized. Gordon (1952) described an aspect of this change in perspective:

> Without a valid method of evaluating aesthetic products, there can be no certainty of progress in art, no clear awarding of prizes in competition, no great and mediocre art, no critics or artists. Without evaluation, every work of art would have equal standing with every other work and all would be equally good and equally poor. (p. 338)

McAdory (1929) discussed the importance of art evaluation in educational and occupational counseling:

> The test may be used to estimate abilities to judge furniture, clothing, architecture, utensils, and similar things . . . . It may be of use also in the selection of

persons for specialized work requiring an understanding of art value; for example, designers, art teachers, stylists, buyers, and salesmen. (pp. 30, 32)

The testing approach emphasized valid and reliable differences between persons, very different from the mathematical relationships formulated by the psychophysicist. Many tests of artistic judgment were developed, several of which were widely used. Some of the most important of these, the Meier Art Tests, Maitland Graves Design Judgment Test, and Proportion Appraisal, are reviewed in this report.

By the 1930s, behaviorism became an important influence in psychology, leading to studies of artistic judgment as a behavioral phenomenon. Behaviorists found that artistic stimulation can serve as a positive reinforcer for behavior, while Maslow (1954) countered this movement by emphasizing art as a basic human need.

Test development and experimental studies of art continued as separate lines of research through the twentieth century until about 1950. Since then, very little test development has occurred with artistic judgment. Most of the contemporary studies of artistic judgment have been experimental, emphasizing a neurological-perceptual understanding of the artistic judgment process. These studies have made a number of advances in understanding artistic judgment, none of which have been applied to the development of an artistic judgment aptitude test. An approach to integrating experimental findings into the development of artistic judgment tests will be examined later in this report.

Conceptual Foundation for an Artistic Aptitude

This chapter introduces the conceptual foundation for contemporary studies of artistic judgment. A comprehensive theoretical background is provided for the reader for understanding artistic judgment research and for evaluating artistic judgment tests.

Attention will first be directed to the evidence for artistic judgment as an individual capacity extending across species. Then consideration will be given to its perceptual development in humans. Next, structuralism, a basic philosophical issue, will be introduced, followed by a discussion of artistic judgment information theory.

At the end of the chapter, the influence of these concepts on artistic judgment testing will be discussed.

Experimental Aesthetics

Decades of artistic judgment studies have led to a research specialization called experimental aesthetics. This is a perspective that views artistic judgment as fundamentally consisting of visual preference judgments that are determined by the physical characteristics of visual stimuli. This approach has investigated preference judgments across species and across stages of human maturation. Some of the main findings are reported here.

Generality of occurrence. Researchers have documented that preferences for visual stimulation occur not only in humans but in other species as well.

In the area of infra-human responses, Sourian (1965) reports that when a spider's web has been altered, it will begin its weaving over again. Rats will press a bar more often to see a cross than to see a square and more to see a square than a circle (Barnes & Baron, 1961). Rats will spend more time in the half of a box decorated with circles than in the half decorated with squares (Harrington, 1966).

Preference judgments in humans can be influenced by a variety of conditions. Psychogenetic factors have been suggested (Eysenck, 1957), and evidence points to the influence of emotional states (Wadlington & McWhinnie, 1973; Karson, 1980). Child (1965) also found a slight correlation between artistic judgment test scores and personality characteristics. In Eysenck's studies (Eysenck & Eysenck, 1976), artistic sensitivity was negatively correlated with psychoticism scores, and artists were significantly more introverted and neurotic than nonartists.

Studies specializing in environmental aesthetics have found that humans prefer slides of natural geographic scenes to urban scenes (Kaplan, Kaplan, & Wendt, 1972), a finding replicated by Calvin, Dearinger, and Curtin (1972) and Fines (1968). Craik (1972) found that humans prefer long or panoramic views.

Artistic perceptual development. Berlyne reported that "by about three months of age, the gaze of an infant is more strongly attracted by visual patterns containing more internal contour, e.g., checkerboards of smaller grain" (1971, p. 185). Bamossy, Scammon, and Johnston (1983) presented evidence for a stage theory approach to artistic development, and Meier (1928) has outlined a time sequence within which children display artistic judgment in the arrangement of their toys.

Researchers have speculated that artistic judgment development is probably subject to the same environmental influences as ordinary visual perception. Their studies with ordinary visual perception have found that differences in the amount of visual stimulation during an infant's early development influence normal perceptual ability as an adult. By

experimentally manipulating visual stimulation during the rearing of laboratory animals, they significantly disrupted visual pathways including the visual cortex (Movshen & Van Sluyters, 1981). Other studies manipulating the vertical contours around animals during rearing produced distorted visual images and permanently altered visual capacity (Cynader, Berman, & Hein, 1976). Some studies have found physiological changes to occur after only three days if distortion occurs during a critical growth period (Freeman, Mallach, & Hartley, 1981). Other well-documented influences on the development of ordinary visual perception are astigmatism, oblique effects, expectancy effects, and cultural variables.

These findings suggest the malleability of artistic judgment development and the influence of prior experience as a possible source of variation in artistic judgments of adults.

There are three key concepts that should be noted from this discussion. First is the general association that researchers have made between visual preference judgments and artistic judgments. Second, artistic judgment is investigated as a broad characteristic that is not restricted to a narrow group of persons or to a specific group of objects or patterns. According to contemporary research, all physical stimuli have some degree of artistic value. Third, differences in ordinary perceptual development suggest that the development of artistic judgment aptitude should vary across persons.

Structuralism

A fundamental concept in all mental testing is an underlying quantitative structure for observations. This perspective, however, is objectionable to many persons when applied to the study of artistic judgment. Art experience is generally considered a spontaneous and unique event not subject to the order of systems or investigative methodology. In the section that follows, the concept of structuralism is discussed as it applies to artistic judgment and information theory.

Philosophy of structuralism. Titchener (1910) emphasized a philosophy called structuralism in his analysis of visual perception as elements and components:

> In Titchener's system, all mental life was reduced to sensory components. The attributes or dimensions of the elementary units were [qualities such as the redness, sourness, or pitch of a stimulus]. (Avant & Helson, 1973)

In Titchener's system, the qualitative mental components were aroused by visual stimuli. This arousal produced neurological receptor sensations that were synthesized into higher-level complexes necessary for producing visual perception. His system was based on the composition of a whole out of elements.

The application of structuralism to visual perception, however, met with strong objections from gestalt psychologists. They rejected Titchener's characterization of sensory elements as ultimate units of perception, emphasizing that perception is always of wholes, forms, and configurations. Wertheimer (1912) rejected the structural notion that wholes are synthesized out of parts, and Kohler (1920) argued that the whole contains meaning exceeding any aggregation of its parts. Titchener's reductionism of sensation was countered by the gestalt emphasis on the organization of elements into intuited wholes. Gestalt psychologists replaced Titchener's introspective structuralism with principles of gestaltism.

Despite the objection of gestaltists, the decomposition of visual stimuli into the elements of an ordered system has continued to influence artistic perceptual theory. By the 1950s, structuralism in the form of information theory was applied to the problem of a basic unit for artistic information and to a clarification of how art experience is perceptually processed.

Two contemporary perceptual theories that are related to problems of artistic perception are the passive data-driven model (Selfride & Neisser, 1963) and the conceptually driven process model (Halle & Stevens, 1962; Neisser, 1967). Both of these approaches assume that artistic judgment depends on a visual scanning operation (Brighouse, 1939; Haber & Hershenson, 1965) in which pattern features such as lines, angles, and curves are perceptually extracted from visual stimuli by specialized neurons in the cerebral cortex (Frisby, 1980). The data-driven system is based on a simultaneous analysis of stimulus features, while the conceptually driven process model is based on the matching of stimulus features against a mental schema.

These perceptual models describe a structure within which a viewer appears to obtain the visual stimulation that is necessary for forming an artistic judgment. These models imply that persons will differ in this perceptual capacity and suggest that test items may be effective for isolating physical characteristics of visual designs that influence an artistic judgment.

Information theory. Information theory applied to artistic judgment explains how humans extract artistic information from the visual scanning of a pattern and relay it to specialized neuron receptors. The key mechanism involved in this approach is the perceptual decomposition of visual stimulation into subcategories of artistic information that are physiologically linked to neuron activity. This is an approach that tries to isolate the various aspects of a visual stimulus that influence a preference judgment and then, with this understanding, hypothesize an information model for artistic judgments.

The simplest of the artistic processing models was proposed by Platt (1961). In his system, an artistic judgment requires a

viewer to perceptually decompose visual stimulation into formal and stylistic levels of information.

Moles (1958) proposed a more elaborate system in which visual stimulation is decomposed into several qualitatively independent levels of information, simultaneously superimposed on each other. He emphasized that "Each level conveys its own unique message and possesses specific rules of organization" (p. 474). Moles made a primary distinction between semantic and artistic information.

Berlyne elaborated the Moles model by dividing visual stimulation into semantic, expressive, cultural, and syntactic levels of art information. Semantic information involves communication that is typical of medieval or commercial art, while the expressive level transmits some personal aspect of the artist. A cultural level suggests that every object is associated with symbols specific to a time and a place, while syntactic information involves the physical configuration of visual elements in an object or pattern.

Another feature of Berlyne's perspective is visual arousal. Based on the preferences of an observer, an object or pattern induces an arousal state in the observer that Berlyne suggests is the basis for artistic satisfaction.

Implications for Artistic Judgment Testing

Aptitude tests generally emphasize human mental characteristics that are not subject to change. Since artistic judgment requires both hereditary and experiential influences for development, an artistic judgment aptitude test should isolate only the part that is independent of the environment. Although no test is currently able to do so, information theory offers an approach for increasing control over the environmental influences on an artistic judgment.

Item construction. Information theory suggests that a typical artistic judgment test item produces several levels of artistic information that simultaneously influence a viewer's preference for it. This means that an individual's perceptual sensitivity or artistic judgment aptitude may only be partially responsible for a visual preference.

Research has consistently shown that the physical configuration of a design is a primary influence on human visual preferences and may be associated with an aptitude. Other aspects of a design, such as the cultural meaning or the style and expression of the artist, also influence preference, but no evidence indicates that they are aspects of a fundamental aptitude.

The application of information theory to the study of an artistic judgment aptitude suggests that test items should be

constructed so that the levels of information in a design are objectively controlled. The artistic information in a design that is associated with an artistic aptitude should be isolated, while all culturally based influences on preferences should be eliminated.

Test validity. Applying information theory to artistic judgment is an example of a structural interpretation of test responses. This is an approach to test validity that implies that the responses to test items should reflect an understanding of the underlying perceptual process for an artistic judgment. It supplements the traditional criteria of test evaluations, such as reliability and criterion-related validity, by emphasizing a consistency between theoretical insights and the underlying system for forming an item response. The structural approach to validity means that a test can be treated not just as a group of items, but as the understanding of an empirical phenomenon.

Empirical Approaches to Artistic Judgment

The systematic study of beauty and numbers goes back to the time of Pythagoras. He is believed to have first pointed out the proportional relationship between changes in the length of a string and differences in their musical octaves, thus establishing a systematic connection between music and number (Eysenck, 1942).

In visual art, scientific studies were begun by Gustav Fechner in the nineteenth century at the University of Leipzig. In what is believed to be the first empirical investigation of human reactions to visual art, Fechner set up, side by side, two versions of Hans Holbein the Younger's Virgin with the Family of the Burgomaster Meyer in a Dresden museum and asked observers to write down their judgments. Concentrating on the relationship between proportion and preference, he reported his findings in an 1865 article (Fechner, 1865).

The empirical study of artistic judgment has involved several assumptions. First is objectivity. An object or pattern is expected to have characteristics that are independent of human perception and are the basis for its valuation as art. Although these characteristics are physical, they have psychological effects and are expected to remain stable and consistent over time.

A second assumption is that a person's artistic sensitivity can be quantified. Lay persons often believe that differences in personal taste or artistic judgment cannot be measured. However, research has shown that personal preferences tend to be stable and can be statistically quantified when analyzed across a set of test items.

A third assumption is the unidimensionality of an artistic judgment test. Mental testing simplifies artistic judgment by assuming that a viewer relies upon a mental idealization of "good" art as an internal standard against which artistic judgments are made. This assumption makes the preference for an object or a pattern the reflection of an underlying unity that is necessary for unidimensional scaling.

These are some of the assumptions that have influenced the empirical study of artistic judgment and have led to the development of aptitude tests. Several examples of artistic judgment tests from this research perspective will now be reviewed.

Mental Testing Approach

McAdory Art Test. Between 1910 and 1950, many artistic judgment instruments were developed. In 1916, Thorndike published the "Scale for General Merit of Children's Drawings" for assessing a child's artistic products (Thorndike, 1916). It was used by raters to compare a child's art work against a standard.

In the 1920s, McAdory constructed one of the first artistic aptitude tests (McAdory, 1929). She selected pictures from common magazines and specialized art sources to produce a test of 72 items. Each item consisted of four similar pictures that had been manipulated on the basis of line arrangement, shape, or color. An examinee was asked to select the picture that he or she liked the best, and the response was scored on the basis of its agreement with a consensus opinion of 100 art experts. The reliability of this test was over .90.

Other artistic judgment tests are the Lewerenz (Lewerenz, 1928), the Knauber (Knauber, 1935), the Meier Art Tests (Meier, 1940, 1963), the Maitland Graves Design Judgment Test (Graves, 1946), and the Barron-Welsh Art Scale (Barron & Welsh, 1952; Welsh & Barron, 1949). Of approximately 20 or more commercial art aptitude tests published during this period, the Meier Art Tests and the Maitland Graves Design Judgment Test were the most thoroughly researched and most widely used.

Meier Art Tests, Maitland Graves Design Judgment Test, and Visual Aesthetic Sensitivity Test. In the Meier Art Tests, each test item consisted of an exact reproduction of an authentic classical painting and a reproduction that was altered on the basis of a design principle. By slightly moving or shifting some element in the reproduction, Meier introduced a flaw that decreased the overall unity or balance of the classic. Studies of his items show that his primary manipulation was a painting's spatial interdependency.

The items in the Maitland Graves Design Judgment Test are designed on the basis of "basic principles of artistic order -

unity, dominance, variety, balance, continuity, symmetry, proportion and rhythm" (Eysenck, 1967, p. 73), although Graves did not publish his method for operationally defining these concepts. A significant advantage of the Maitland Graves Design Judgment Test over other tests was the use of original nonrepresentational art works. This diminished the influence of cultural background and art training on item responses that occurred with authentic art works.

Although the Meier Art Tests and the Maitland Graves Design Judgment Test were widely used, several theoretical issues arose. One was the relationship of these tests to intelligence. Bolton (1955) reported correlations between the Meier Art Tests and general intelligence ranging between .36 and .43. As measures of an independent aptitude, the Meier Art Tests should correlate less than .20. The Maitland Graves Design Judgment Test fared better, correlating .10 and .19 with intelligence.

Another issue concerned the lack of correlation between the Maitland Graves Design Judgment Test and the Meier Art Tests, or between any two tests of artistic judgment (Millman & Chang, 1966). A typical example of the correlation between the Meier Art Tests and the Maitland Graves Design Judgment Test is .35, as reported by Bolton (1955). This was replicated by Eysenck (1972a), who found that although the Maitland Graves Design Judgment, the Child, and the Birkhoff Polygon tests all significantly differentiated art students from nonart students, the tests failed to intercorrelate. This indicates a lack of consistency in the underlying construct for the tests and leads to an ambiguity regarding the aptitude tested.

These findings have led some investigators to conclude that each test is measuring a different aspect of artistic judgment, probably based on specialized art training. Bolton found that "those who had taken art courses ranked 9 percentiles higher on the Maitland Graves test and 6 percentiles higher on the Meier test" (Bolton, 1955, p. 221).

A review of these tests is summarized by Barrett (1949):

> They appear, however, to be more in the nature of achievement tests than of native ability tests, i.e. scores are influenced by the nature and amount of previous training. (p. 400)

Eysenck concluded in 1972 that there may not be a unitary single ability called artistic sensitivity:

> It must be concluded that there may be no unitary single ability rightly called 'aesthetic sensitivity'; instead we may be dealing with fragmented and partial sensitivities. (Eysenck, 1972a, p. 555)

The notion of a unidimensional art aptitude, however, has recently received empirical support from a study by Gotz, Lynn, Gorisy, and Eysenck (1979). They have reported support for a new artistic sensitivity test, called the Visual Aesthetic Sensitivity Test, based on Eysenck's extensive factor analytic research. Initial findings indicate that the items are closely interrelated, forming a single art aptitude factor with very little remaining variance. The designs in the test are also artistically produced, an important improvement over some of the earlier tests.

Proportion Appraisal. According to available research reports, until 1939 the Johnson O'Connor Research Foundation relied primarily upon the McAdory Art Test as its measure of artistic sensitivity. The McAdory Art Test was first published in 1929, although it is not clear when the Foundation began using it. Due to its practical orientation (items were photographs of typical household articles) and high reliability, it appears to have been a useful tool.

By 1939, however, three problems were recognized with the McAdory Art Test. They were: (a) the test items were old-fashioned in appearance; (b) the administration time for the test was over an hour; and (c) the items lacked an overriding design principle.

The first problem received O'Connor's attention (O'Connor, 1940):

> Plates of the McAdory test which portrayed four modern dresses, four up-to-date sweaters, or four women's suits, at first satisfactory, became within a few years old-fashioned, and by arousing disparaging comments robbed the test of interest and of apparent worth. The ten years required to standardize and validate each new test preclude therefore, the use of modern articles. (p. 113)

A second problem was that the 72-item McAdory Art Test required an hour or more for administration. This did not leave enough time for the remainder of the Johnson O'Connor laboratory program.

A third problem with the McAdory Art Test was the lack of a theoretical foundation for item construction:

> One of two weaknesses of the McAdory Art Test, from which sprang the Laboratory's present proportion-appraisal test, was that among the popular choices there appeared no recognizable principle. (O'Connor, 1948, p. 121)

These issues lead to a move to "purify" the McAdory Art Test (Technical Report 23). Relying upon an analysis of quartile and median ratios, Horton identified a significant subset of 36 items from the original 72-item test. Unfortunately, the reliability

of the subset (which was labeled Worksample 172 Form AB) dropped to .71.

In 1939, Horton also reported on an effort to reduce the number of factors involved in the construction of the McAdory Art Test (Technical Report 23). In the original test, McAdory manipulated several variables relating to the color, shape, mass, and line arrangement of a picture. Horton believed that reducing the number of factors would improve the reliability of the Foundation's shorter form. In the spring of 1938, Horton constructed Worksample 235 (Experimental Proportion Appraisal Test), reducing all sources of influence on an item's preference to only its proportionality. The arithmetic specifications for constructing these items were reported in Technical Reports 44 and 99. Worksample 235 represented a major departure from the McAdory Art Test in that the items were no longer typical household items, but polygons that were scored correct according to popular opinion. The reliability of this 10-item experimental test was an encouraging .53. Based on the Spearman-Brown prophecy formula, a test constructed on this basis would only need 36 items to reach a reliability of .80. Seventy-two items would be needed to reach a reliability of .90, the length of the original McAdory Art Test. A 50-item version of Proportion Appraisal (Worksample 235, Form B) was constructed in 1946 (Technical Report 251) with a reported reliability of .70. Validation studies of Proportion Appraisal (Worksample 235, Form B) are reported in Technical Report 251.

In 1946, the Maitland Graves Design Judgment Test was published. Between the late 60s and the early 70s, the Foundation began substituting it for Proportion Appraisal in the Foundation battery. The Maitland Graves Design Judgment Test consisted of relatively culture-free stimulus designs that were constructed on the basis of art principles and validated by groups of artists and nonartists. A reliability of .86 was reported for the test (Technical Report 792), and items were scored correct on the basis of agreement with artists.

Two major studies were conducted by the Foundation comparing Proportion Appraisal and the Maitland Graves Design Judgment Test (Statistical Bulletin 1975-6; Technical Report 792). In the first study, Leshikar and Quimby found that a 13-item subset of the Maitland Graves Design Judgment Test, discovered by Eysenck (1967) to be unidimensional, correlated -.32 with Proportion Appraisal (Worksample 235 BE). In a second study Shambaugh (Technical Report 792) found that the full 90 Maitland Graves Design Judgment items (Worksample 654 A) correlated -.43 with Proportion Appraisal (Worksample 235 BE). However, the invalidation of the Maitland Graves Design Judgment Test by Eysenck (1970a, 1971a) limits the meaningfulness of these two studies. In the 1970 study specifically, no significant differences were found between artists and nonartists on the Design Judgment Test, suggesting that it should not be considered to be a valid test of artistic judgment. Consequently, the

correlation between the Design Judgment Test and Proportion Appraisal is difficult to interpret. No further artistic judgment research appears to have been conducted since these studies were reported.

Quantitative Approaches

The cornerstone for contemporary methods of statistical item analysis is the 19th century psychophysical studies of Fechner. This section will provide an introduction to his perspective and will suggest implications for the valid testing of an artistic judgment aptitude.

Fechner's psychophysics. The goal of the psychophysicist is to portray wide-ranging patterns of observations with simple mathematical formulations. The classic application of this approach to artistic judgment is the studies reported by Fechner in Leipzig in 1865.

Fechner originally approached artistic judgment as a generalization of Weber's Law. Weber's Law relates the size of the JND, or just noticeable difference (which is the increase in the magnitude of a stimulus characteristic necessary for an observer to experience a psychological change in sensation), to the intensity of a standard stimulus so that:

$$\Delta I = KI,$$

where ΔI is the size of the JND, I is the intensity of the standard stimulus, and K is a constant.

Weber's Law quantitatively identifies the minimum difference in magnitude necessary for human discrimination of two stimuli, and research has found it to be accurate for data in the middle of a response distribution. However, it was originally formulated for physical variables. Fechner's insight was to adapt Weber's law to the relationship between psychological preference judgments and the physical proportions of polygons.

Fechner did this by first assuming that the psychological impression of differences between two stimuli separated by 1 JND was the same regardless of the absolute physical magnitude of the stimuli. He then treated the differences between JNDs as though they were additive and numerically concatenated the differences as psychological sensations. The relationship between sensation intensity and physical stimulus magnitude is called Fechner's Law and is represented by

$$S = K \log I$$

where S is the magnitude of a sensation that a stimulus elicits, I is the physical magnitude of the stimulus expressed in physical units, and K is a constant.

In these studies Fechner was investigating an artistic rule known as the golden section (Berlyne, 1971). According to this rule, art is most beautiful when the length and breadth of an object or pattern are in a ratio of .618:1. Fechner (1865) concluded that the relationship between the golden section and preferences was proportional.

In the 1920s, Louis Thurstone corrected Fechner's finding. Thurstone applied one of his own methods for psychological measurement (Thurstone, 1925) to Fechner's data and found a logarithmic relationship.

Fechner's approach represents an important landmark in the experimental study of artistic judgment. His mathematical identification of a relationship between a stimulus characteristic and preference ratings demonstrated the usefulness of empirically investigating artistic judgment. Some ways in which his work has influenced the development of mental tests in general are the following:

1. emphasis on maintaining standardized test conditions,
2. development of techniques for precisely measuring psychological variables, and
3. formulation of mathematical abstractions for portraying empirical relationships.

Other psychophysical techniques that have been adapted for artistic judgment experiments are: (a) magnitude estimation, (b) paired comparisons, (c) method of constant stimuli, and (d) method of equal appearing intervals.

Birkhoff's mathematics. During the first half of the twentieth century, George Birkhoff was a leading mathematician, noted for his work in general dynamics, the theory of orbits, and his investigation of the ergodic hypothesis. In the 1920s, he formulated a mathematical treatment of artistic judgment.

Although Birkhoff preceded information theory by several decades, his approach to artistic experience hypothesized a system of three phases in the process of forming an artistic judgment:

> The typical aesthetic experience may be regarded as compounded of three successive phases: (1) a preliminary effort of attention, which is necessary for the act of perception, and which increases in proportion to what we shall call the complexity (C) of the object; (2) the feeling of value or aesthetic measure (M) which rewards this effort; and finally (3) a realization that the object is characterized by a certain harmony, symmetry, or order (O), more or less concealed, which seems necessary to the aesthetic effect. (Birkhoff, 1956, p. 2185)

Emphasizing the harmonious artistic interrelations within a pattern, he proposed a formula,

$$M = O/C,$$

where M is an artistic measure that is a function of order and complexity. This means that in any pattern, artistic value is always greatest when the order is maximized relative to the complexity. At any level of complexity, an increase in order will increase the overall aesthetic value of a design.

In 1932, Birkhoff published a set of polygons (Birkhoff, 1932) that he constructed on the basis of his mathematical theory. In these polygons, he measured the complexity (C) by counting the number of sides in a polygon. His measure of order was dependent upon a preference reaction that he called "aesthetic tone." This was either a positive, negative, or zero value depending upon the pattern's physical characteristics. By adding together the separate occurrences of order and disorder, he established what he called a pattern's "tone value." In the following quotation from Birkhoff, u, v, and w represent the number of times that l, m, and n occur in an object or pattern. By adding them together, a measure of order is established:

> L, M, N, . . . correspond to what have been termed the elements or order in the aesthetic object. Thus we are led to write
>
> $$O = ul + vm + wn + \ldots$$
>
> (Birkhoff, 1956, p. 2191)

Although subsequent research has found the performance of his mathematical model to be unstable (Beebe-Center & Pratt, 1937), his suggestion that an additive function underlies an object's aesthetic value remains fundamental to contemporary research. His identification of complexity and order as key variables was a conceptual breakthrough in understanding artistic judgment that has had a major influence on subsequent research. His view of artistic perception as a succession of discrete stages was the forerunner of the contemporary application of information theory to experimental aesthetics.

Eysenck's factor analysis. Research in the objective understanding of artistic stimuli was carried on from the 1940s through the 1970s by Hans Eysenck. Influenced by the work of Fechner and Birkhoff, Eysenck conducted factor analytic studies into the preference for polygons.

Theoretically, Eysenck worked from a physiological perspective:

> The hypothesis that there exists some property of the central nervous system which determines aesthetic judgments . . . . People would be expected to differ with respect to "good

taste" in the same way in which they are known to differ with respect to acuity of vision. (Eysenck, 1957, p. 319)

Eysenck believed that the judgments commonly made regarding "beautiful" and "ugly" have a biological foundation, and he emphasized a genetic influence. This led to his perspective that artistic judgment is a form of visual perception that develops on the basis of learning and conditioning:

> Rules for the perception of these qualities (roundness and squareness) had to be acquired, just as we have to acquire rules for the perception of beauty; without these rules there is literally no perception at all. (Eysenck, 1957, p. 312)

Eysenck's perspective broadened the approach to artistic judgment by hypothesizing an explicit relationship with physical theory. Using the perception of color as an example, he argued that objects do not have the intrinsic property of beauty, just as they do not have the property of color. Objects only possess physical properties that consistently absorb and reflect certain wavelengths of light. Humans perceive the differences in wavelength, finding certain combinations more pleasing than others. Individual differences in preference for any given combination of wavelength and physical form are the empirical bases on which artistic judgments are made:

> An object does not "contain" beauty in any meaningful sense of the term; it reflects light in certain combinations of wavelengths which some people experience as "beautiful", others as "ugly" or "indifferent". (Eysenck, 1957, p. 311)

Eysenck's physiological perspective implies that neurological and perceptual differences between persons influence the character of their artistic judgments. His hypothesis that some persons are more sensitive to particular combinations of light waves than other persons suggests that a spectrum or band concept of artistic judgment is plausible. This means that just as human sensitivity to light is characterized by a specific bandwidth, artistic sensitivity may also have a bandwidth associated with persons of highly sensitized perceptual capacities.

Eysenck's key proposition was a generalized artistic capacity, similar to psychological views on intelligence. He thought that ". . . we might be dealing with some underlying aesthetic ability or 'good taste,' demonstrated in all sorts of visual preference judgments and independent of intelligence, training and other external factors" (Eysenck, 1971b, p. 163).

Eysenck was not the first researcher to suggest a general perceptual capacity extending across all preference judgments. Both Burt (1933) and Dewar (1938) had previously explored the

proposition. However, no one had tested the theory with Eysenck's degree of comprehensiveness. In his factor analytic studies, Eysenck found a general factor that ". . . was shown to extend over eighteen different tests of visual artistic appreciation, and to correlate with factors extracted from tests for colour appreciation, appreciation of polygonal forms, and preference for odours" (Eysenck, 1941a, p. 262). He called this generality across racial and national groups a "T" or taste factor (Eysenck, 1940). A visual inspection of his "T" factor shows items that are characterized by vertical and horizontal symmetry (Eysenck, 1942). His finding of a general factor is consistent with Granger (1955) but unsupported by Child (1964).

In a study of preferences for polygons, Eysenck (1968) found evidence for a simplicity factor on which artists tend to value simple polygons more highly than do other persons. A later study (Eysenck & Castle, 1970) clarified the meaning of this finding. In this second study, artists did not differ significantly in their preferences for simple and complex polygons, although control subjects had significantly greater preferences for complex polygons.

In his studies of color preferences, Eysenck (1941b) found another bipolar factor, correlating .53 with the T factor, that divides the population into groups preferring pure, highly saturated colors from those who prefer relatively unsaturated colors (i.e., tints and shades). In general, he found a direct positive relation between liking for a color and its differentiation from white. This is consistent with the findings by Cohn (1894) that the more saturated colors were more highly preferred.

In a study dealing with preferences for pictures of landscapes and portrait paintings, Eysenck discovered another factor that he called "K." The "K" factor divides the population into types:

> [Eysenck] . . . added the discovery of a second important factor determining aesthetic preferences; this contrasted subjects preferring bright colours and modern pictures, to subjects preferring darker and more subdued colors and more old-fashioned pictures. (Eysenck, 1972a, p. 545)

Based on these results, Eysenck suggested revising Birkhoff's formula for order and complexity so that they are directly proportional in their relation to aesthetic value. This is closer to Fechner's original relationship:

> It will be clear from simple inspection that the better liked designs are much more complex, thus giving a direct, and not an inverse relationship between M and C (Eysenck, 1971b, p. 164)

Another conclusion related by Eysenck was that artistic judgment is an aptitude not dependent on art training or cultural experience.

Psychobiological Approach

Arousal reduction mechanism. In the 1960s, Berlyne developed a psychobiological approach to artistic judgement. This emphasized a biological role for artistic judgment, related to the process of natural selection and adaptation. Berlyne speculated that just as the capacity to think and reason presumably gave humans an evolutionary advantage over natural enemies, artistic perception should also have a role in evolution and human survival. His studies with artistic judgment were directed at understanding this relationship.

His research led to a hypothesis that organisms have a preferred or optimal level of stimulus arousal necessary for efficient performance (i.e., survival). Major deviations from an optimal state influence the organism's overall adaptive capacity, thus affecting survival. According to this view, in order to maintain an optimal level of arousal, individuals will seek visual stimulation.

Application of information theory. Berlyne's arousal level hypothesis led to an investigation of the physical characteristics of patterns and designs that influence preference. For this reason, Berlyne applied information theory to the study of artistic judgments.

According to information theory, every physical object carries some amount of artistic information to which a viewer responds during perceptual processing. Berlyne (1971) proposed an artistic information system in which perception changes the information in visual stimuli into four levels of artistic characteristics that in turn influence preference judgments. He called these levels semantic, syntactic, expressive, and cultural sources of artistic information on a viewer. He emphasized the syntactic level as basic to all art forms.

> All art has . . . syntactic information transmission . . . . the appreciator must to some extent be responding to relations between the physical properties of different elements (p. 150)

Within these levels, an artist creatively manipulates variables such as complexity, novelty, and ambiguity that produce arousal states and preference reactions in an observer (Berlyne, 1974).

Both Berlyne and Eysenck agree that artistic judgment also has wider influences on the formation of personality characteristics.

> In this chapter an effort has been made to argue that the biologically determined, innate differences in resting arousal level constitute intrinsic motivating factors which, . . . produce personality differences . . . which in turn mediate many different types of behavior. (Eysenck, 1981, p. 146)

An important general finding of Berlyne's perspective is a curvilinear relationship between the complexity of a design and the preference for it. This finding suggests that the complexity in a pattern may be an effective means of identifying persons who differ in their artistic judgment.

Discussion

Review of Research Findings

After over a hundred years of research, an empirical understanding of artistic judgment is forming. Although tests of known validity and high reliability are not yet available, research has established a considerable understanding of how artistic judgments are formed and some of the physical characteristics that influence human preferences for patterns and designs. Any future test of artistic judgment will probably be based on an application of these relationships.

In the next section, the factor analytic, psychobiological, and gestalt perspectives will be examined more closely for their implications for artistic judgment testing.

Statistical studies. Factor analytic results have found that nonartistically trained viewers consistently prefer symmetrical designs (Eysenck, 1971b). These findings are supported by Eysenck's (1971a) analysis of the Maitland Graves Design Judgment Test, where artists preferred asymmetrical designs.

The influence of complexity on preference judgments, however, is less clear. Factor analytic findings indicate that, in general, higher complexity is positively associated with higher preference by nonartist observers. Eysenck (1971b) noted that "it will be clear from simple inspection that the better liked designs are much more complex" (p. 164). Berlyne (1971) also found that preference generally increases as complexity increases up to a point, but that beyond that point, preference declines. The Eysenck and Berlyne findings, however, are inconsistent with the results of Munsinger and Kessen (1964) and Barron and Welsh (1952). They found that higher levels of complexity were preferred by viewers with a background in art and presumably more art experiences than those without artistic backgrounds. Vitz (1966) found the same relationship with music (i.e., subjects with high interest or training in music preferred higher levels of complexity).

Psychobiological studies. The finding by the psychobiologist Berlyne that preference for complexity follows an inverted-U function may help to clarify the differences found between artists and nonartists. It may be the case that, for artists and nonartists, preference follows the inverted-U function, but with different points for the peak of the curve. Gestalt research

suggests that this difference may be attributable to the Law of Pragnanz.

Law of Pragnanz. The Law of Pragnanz is a gestalt principle that describes a viewer's perceptual tendency to correct distortions in an image in order to produce the "best" overall pattern. Investigators (Garner & Clement, 1963; Hochberg & Brooks, 1962; and Kopferman, 1930) found that higher levels of complexity were related to judgments of goodness if the overall configuration of a design was reducible to a simpler pattern. This was reinforced by the work of Handel and Garner (1965), who found that complexity were related to goodness of pattern if some form of uniqueness could be identified within a complex stimulus field. In their study, uniqueness was operationally defined as the number of different patterns produced when a design was physically rotated. These findings suggest that the capacity to make holistic reductions of complex stimuli mediates the influence of complexity on preference judgments and is probably involved in a fundamental understanding of how complexity influences preferences for visual art.

The role of uniqueness in a complex visual field may also be associated with the influence of redundancy on visual preferences. Uniqueness in a highly complex pattern is generally characterized by small amounts of repetition or redundancy (Attneave, 1959). The highly sensitized visual receptors of the artist may be easily stimulated by subtle redundancy features. What would otherwise be considered very complex patterns may lead to high preferences by artists because the redundancy organizes the pattern into a simpler whole. This capacity to simplify complex fields into simpler ones may not be possible for nonartists because of lower visual sensitivity.

While speculative, these considerations suggest that test items that have complexity and redundancy manipulated may provide a basis for distinguishing between artists and nonartists. A reasonable approach would be to impose subtle patterns on highly complex designs to determine whether the discriminative mechanisms that presumably operate on an artist's perception may be isolated and whether they are absent from nonartistic viewers.

Artistic Judgment Testing Issues

Scale validation. A problem for most of the artistic judgment tests is the use of expert judges in their validation. Eysenck (1970a) argued that test validation by external criterion groups is always vulnerable to the differences produced by another group of arbitrarily selected judges. This criticism of validation by external criterion groups is especially important with artistic judgment testing because Getzels and Csikszentmihalyi (1969) found only a .33 correlation between ratings of individual expert art judges.

It was to the instability of art ratings, as well as a shift in intergenerational art values, that Eysenck attributed his failure to replicate Graves's statistically significant 28-point difference between art and nonart students. Twenty years later, Eysenck found a difference of only 4 points.

Criterion problem. A problem related to scale validity is the scoring of item responses. Eysenck's suggestion was to correlate individual "ratings with the average of all the other raters and thus obtain a score indicative of [an individual's] 'conformity'" (Eysenck, 1971a, p. 163). Thus Eysenck defines the group average as the standard for "good" art. This is similar to an approach proposed by Child (1964). Although this method evaluates item responses without reference to an external standard, it produces another problem. Since the average becomes the standard, persons that are typically considered to have high artistic sensitivity will not be identified. Individuals with extreme sensitivity scores can only be identified as significantly different from the group norm, not as artistically more sensitive. This creates a fundamental problem in terms of the validity of the test.

The scoring of test responses has been a persistent problem. Meier's (1940) approach was to use reproductions of recognized masterpieces, thus establishing wide agreement for their artistic value. As test items, the masterpieces were paired with reproductions that had been slightly modified. Although there was no need for expert judgment or correlation with a group mean, the test was invalidated as a measure of an artistic judgment aptitude because cultural background and prior artistic experience were found to influence scores (Barrett, 1949; Bolton, 1955).

Psychometric analysis. Another issue deals with the psychometric characteristics of artistic judgment tests. In general, most of the instruments have not been adequately analyzed for internal-consistency reliability and validity. Only the Maitland Graves Design Judgment Test (Eysenck, 1967, 1971a) and the Barron-Welsh Art Scale (Eysenck, 1970b) have been thoroughly examined. None of the tests have been examined by a contemporary method of item response theory.

In a factor analytic study of the Maitland Graves Design Judgment Test (Eysenck, 1967), a unidimensional structure was not supported for the 92 items. Eysenck found several unrelated factors, as well as an interaction with sex, and advised against administering the 92 items as a single group. He did identify a subset of items for which the Maitland Graves Design Judgment Test appears unidimensional and suitable for valid use.

Eysenck (1970b) also found the unidimensionality of the Barron-Welsh Art Scale to be inadequate. Four factors were identified and found to be entirely independent of each other.

Eysenck interpreted the test's structure as consisting of a simplicity factor and three different complexity factors.

Recommendations

The purpose of this research review was to identify one or more instruments that may be useful for the reliable and valid assessment of a person's artistic judgment. Unfortunately, the review concludes that there are no generally accepted tests of artistic judgment. Although the reliability of several of the tests exceeded .90, the validity in general is unknown. There are several tests that successfully isolate fragments of an artistic judgment aptitude, but none of them appear adequate as an independent measure. The only promising test is the Visual Aesthetic Sensitivity Test (Gotz et al., 1979), which is based on Eysenck's extensive factor analytic research.

The Johnson O'Connor Research Foundation's Proportion Appraisal worksample isolates a component of artistic judgment necessary for detecting differences in patterns' proportions. The Maitland Graves Design Judgment Test identifies sensitivity to differences in symmetry. The Meier Art Tests emphasize the capacity to detect flaws in a design's spatial arrangements. Although each test is at least moderately reliable, they fail to intercorrelate with each other, suggesting that each test is dealing with a different aspect of artistic judgment.

An artistic judgment test for the Foundation battery will probably require a major integration of the artistic judgment research into a new instrument. Much of the theoretical work for this has already been done through the application of information theory to artistic judgment by psychobiologists. However, no instrument has yet been constructed.

These general considerations lead to the following two recommendations for this project:

1. Test comparisons. Select several artistic judgment tests that are already developed and compare them with Proportion Appraisal and an artistic judgment information processing instrument to be developed by JOCRF (see specifications in Appendix A and sample items in Appendix B). These tests would be field-tested and analyzed to determine which one or combination of several tests should be used in the battery.
2. Validation. The tests that are selected and developed for the test comparison study should be examined for criterion-related and construct validity.

Test Comparisons

The first recommendation is to compare an instrument constructed on the basis of information theory to several

traditional artistic judgment tests. This will involve two steps. First, an artistic processing instrument will need to be constructed and pilot tested. Then an experimental battery will need to be organized for empirically comparing the new test with a set of traditional artistic judgment tests.

Artistic processing instrument. The construction of an artistic judgment test based on theoretical information processing principles involves the following four activities: (a) identification of information components that distinguish between artists' and nonartists' preferences for visual stimuli; (b) establishment of an objective methodology for the construction of items; (c) identification of fundamental hypotheses that test the instrument's construct validity; and (d) application of a method that evaluates whether examinees' responses to items conform to the predictions of information theory as applied to artistic judgment.

The following principles have been extracted from a review of the research and will probably be useful for constructing test items that operationally define artistic judgment:

1. Artistic information is embedded in all visual stimuli.
2. Preference judgments are associated with a visual design's complexity, redundancy, and symmetry.
3. An artistic judgment is formed by the combination of many separate elements in a pattern or object.
4. A viewer organizes the artistic information in a design into perceptual units.

These principles can be applied to generate items with objective artistic characteristics by implementing Attneave's (1959) "Stochastic Composition Processes." His technique can be adapted so that complexity and redundancy characteristics in a design can be objectively manipulated.

A small group of items have been constructed at the Foundation on this basis. Although the sample size was too small (N = 8) to make any definite statements, the results are promising. The next phase of item generation would involve extending the scale by refining the items and increasing their number. These items then should be tried out in a pilot phase with 200 adults to assess their psychometric adequacy.

Experimental battery. The proposed artistic judgment processing instrument should be organized into an experimental battery with the JOCRF Worksample 235, called Proportion Appraisal; the unidimensional subset of the Maitland Graves Design Judgment Test; and the Visual Aesthetic Sensitivity Test. The purpose of this study would be to compare the item difficulty distributions and reliabilities of the tests.

Validity Study

The second recommendation of this report is for a validation study of the tests in the experimental battery. Because of the importance of this issue, it will be handled in three ways.

Criterion-related validity. First will be the traditional method that involves examining test scores for a criterion group of artists, in comparison to scores of nonartist JOCRF examinees.

Component analysis. A second approach to validity will focus only on the artistic judgment processing instrument. A statistical method will be used to analyze the information components that were used in constructing the items. This will determine whether the ratings of test stimuli are quantitatively organized in a manner consistent with theoretical predictions to be presented subsequently. This approach to relating the order in test responses to the construction of items was introduced by Sternberg (1979) with intelligence tests:

> The placement of tasks in the hierarchy is dictated by the class components that are used to perform each task. Tasks are arranged in ascending order of complexity; the class components of information processing pertinent to tasks lower in the hierarchy are also pertinent to tasks higher in the hierarchy. Thus tasks at higher levels in the hierarchy require for their solution concatenations of class components required for solutions of tasks lower in the hierarchy. (p. 223)

According to Whitely (1980), "the tasks demonstrate construct validity in that their selection has been guided by a sub-theory of intelligence and the tasks have been shown to be empirically valid indicators of the mental abilities they are supposed to measure" (p. 219). She describes how the application of the Rasch measurement model to the componential theory of intelligence empirically supports construct validity in two ways.

> First, a latent trait model is, in essence, a theoretical account of individual differences in ability test performance . . . . The model provides a very powerful account of performance, as response predictions are given for individual subjects encountering specific items. Unlike classical test theory, latent trait models explicitly consider the cognitive task in predicting performance.
>
> Second, the meaning of ability is clarified because scores may be interpreted directly with respect to performance in the item set. (p. 113)

Because the artistic judgment processing instrument has been constructed on the basis of objective components, the extent of

consistency between examinees' item responses and theoretical expectation can be assessed through statistical analysis.

Theoretical hypotheses. Finally, a formal set of hypotheses has been derived from the research literature. The results from analyses of these hypotheses will permit the Foundation to determine whether the application of objective information components to visual designs, as a basis for the construction of an artistic judgment instrument, is empirically sound. These findings should provide additional support for the results of the component analysis.

Hypothesis 1. The factor analytic findings suggest that preferences for designs increase as the complexity of designs increases. This hypothesis will be examined by comparing item response calibrations with item complexity specifications for the same set of items.

Hypothesis 2. Information theory assumes that artistic information in a design is perceptually processed as a sequence of components. This hypothesis will be tested by an effect-coding of the items based on the item construction rules and the subsequent regression of the item response calibrations on the effect codes. If an additive model of the effect codes successfully accounts for the item calibrations, this finding will be consistent with the hypothesis.

Hypothesis 3. The literature suggests that complexity is a key variable in differentiating between artists and nonartists. Research indicates that subtle patterns imposed on complex designs should be especially effective for distinguishing between artists and nonartists. The validity of this conclusion can be assessed by the objective manipulation of redundancy in highly complex test items. The expectation is that when there is no redundancy, artists will prefer simpler designs, and nonartists will prefer complex designs. Complex items that have been manipulated to produce low-to-moderate levels of redundancy will be preferred by artists, while complex items with high redundancy will be preferred by nonartists.

Summary

A literature review of artistic judgment aptitude testing has been presented. The literature perspective was broad, including major areas of artistic judgment aptitude testing and experimental aesthetics. Findings regarding an association between individuals' preference judgments and their quality of artistic judgment were discussed, and the neurological development of artistic judgment was introduced. Basic issues in the philosophy of structuralism were also related to the development of artistic judgment tests.

The survey of artistic judgment instruments concluded that:

1. The use of artistic principles in the construction of the instruments was generally weak.
2. Validity was not adequately established for any of the tests.
3. The evidence for a unidimensional construct for artistic judgment is not strong.

A review of experimental findings indicated areas in which empirical findings are consistent and should be investigated for their artistic judgment testing implications. The main findings are that:

1. The complexity of a design has a strong influence on a viewers' preferences.
2. Variations and irregularities in a pattern influence preference.
3. Symmetry has an influence on preference.

The review of artistic judgment tests and experimental findings led to the following recommendations:

1. Design a group of items that can distinguish between artists and nonartists on the basis of experimental findings. A specific recommendation was made to define operationally the concepts of complexity and redundancy in an artistic judgment processing instrument.

2. Compare several of the major artistic judgment instruments in a large-sample correlational study.

3. Design a validation study for a new artistic judgment processing instrument and several traditional artistic judgment instruments.

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Appendix A

Item Construction Specifications

A. Complexity Component

(low to high pattern complexity with zero pattern redundancy and zero grid redundancy)

1. Divide an 8 by 11 sheet of gridded fade-out paper (specially printed grids that do not reproduce on a copy machine) into 88 1 x 1 inch squares. Going from left to right, sequentially number the grid pattern from 1 to 88 with a blue editing pencil.
2. There are 4 nonrepresentational pattern elements used in this study. They are a horizontal, a vertical, and 2 diagonal bars (—, |, /, \). Arbitrarily select one of the pattern elements. (For this explanation, — will be used.)
3. On 3 sheets of gridded fade-out paper, use a random number table to assign the pattern element (—) to two, four, and eight positions, respectively.
4. On 3 additional sheets of gridded fade-out paper, repeat the operations from A. 1., 2., and 3., but with 2 different pattern elements. Randomly assign each of the 2 pattern elements (—, |) to 2 positions on the same sheet. On 3 more sheets, randomly assign each of 4 different pattern elements (—, |, /, \) to 2, 4, and 8 positions, respectively. This last step should produce 3 designs of 8, 16, and 32 total assigned positions.

B. Complexity Component and Redundancy Component

(low to high pattern complexity with high pattern redundancy and medium grid redundancy)

1. Using an editing pencil, horizontally divide 9 gridded fade-out sheets into halves. Each half of a gridded fade-out sheet is called a panel and is numbered p-1 and p-2, respectively.
2. Randomly assign 1 pattern element (—) to 2 positions of p-1 on one gridded fade-out sheet.
3. Assign the pattern element (—) to the same 2 positions on p-2 of the grid. This repetition of pattern elements from one panel to another establishes 100% pattern redundancy.
4. Increase the overall complexity of the design by assigning the pattern element (—) from B. 2. to 4 positions on p-1 of a sheet of gridded fade-out paper. The pattern element (—) is then assigned to the same 4 positions on p-2. Next assign the pattern element (—) to 8 positions of another gridded fade-out sheet and to identical positions on p-2.
5. On 3 sheets of gridded fade-out paper, repeat steps B. 1., 2., 3., and 4., but use 2 different pattern elements (—,|), simultaneously. On three more sheets of gridded fade-out paper, use 4 different nonrepresentative pattern elements (—, |, /, \).

C. Complexity Component and Redundancy Component

(low to high pattern complexity with 100% pattern redundancy and high grid redundancy)

1. Horizontally divide 9 gridded fade-out sheets into four equal sections. Each section is called a panel and is numbered sequentially p-1 through p-4.
2. Randomly assign 1 pattern element to 2 positions on panel p-1.

Assign the identical pattern element to the same 2 positions on panels 2 through 4. This produces a stimulus with high grid and high pattern redundancy.

3. On 2 sheets of gridded fade-out paper, increase the complexity of the overall design by randomly assigning the pattern element (—) from C. 1. and 2. to 4 positions and 8 positions, respectively. On the sheet with 4 positions assigned to p-1, assign the pattern element to identical positions on p-2, p-3, and p-4. On the sheet with 8 positions assigned to p-1, assign the pattern element to identical positions on p-2 through p-4.

4. Pattern complexity is further manipulated by repeating C. 1., 2., and 3. on 3 sheets of gridded fade-out paper with 2 different pattern elements (—, |). Next, on 3 additional sheets of gridded fade-out paper, complete the operations from C. 1., 2., and 3. with 4 different pattern elements (—, |, /, \).

D. Complexity Component and Redundancy Component
(low to high complexity with medium grid redundancy and 50% pattern redundancy)

1. Horizontally divide 9 sheets of gridded fade-out paper into halves and number them p-1 and p-2.

2. Randomly assign 1 pattern element (—) to 2 positions on p-1.

3. Randomly select 1 of the pattern elements from p-1 and assign it to the identical position in p-2. Reassign the remaining element from p-1 to a random position in p-2. The result is an overall design with 50% pattern redundancy.

4. The complexity of the overall design is increased by repeating steps D. 1. and 2. on two additional sheets of gridded fade-out paper with 4 and 8 pattern elements, respectively. As in D. 3., 50% of the pattern elements are randomly reassigned from p-1 to p-2. The remainder are reassigned to identical positions in p-2. If an element that is randomly reassigned from p-1 to p-2 falls on a position originally assigned in p-1, another position needs to be randomly selected. This ensures that the 50% random reassignment does not duplicate positions between p-1 and p-2.

5. Repeat steps D. 1., 2., 3., and 4. with 2 (—, |) and 4 (—, |, /, \) pattern elements. Follow the method of partial redundancy (50%) described in step D-4.

E. Complexity Component and Redundancy Component
(low to high pattern complexity with 50% pattern redundancy and high grid redundancy)

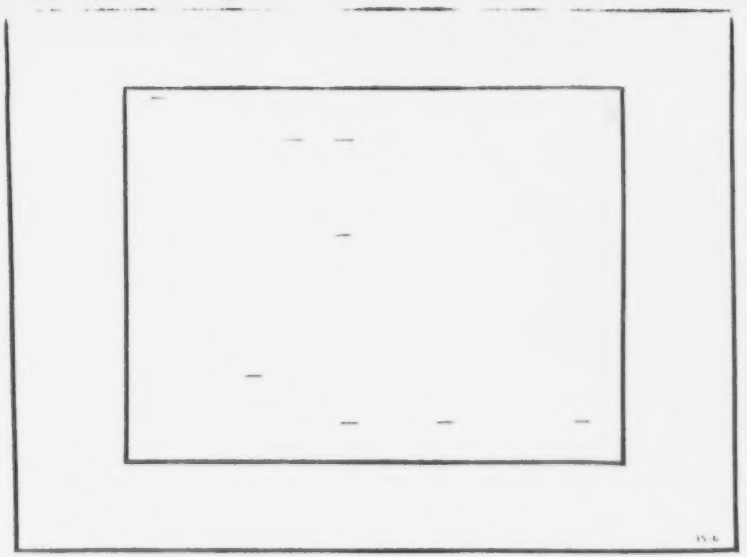
1. Horizontally divide 9 sheets of gridded fade-out paper into 4 panels. On one sheet of gridded fade-out paper, randomly assign 1 pattern element (—) to 2 positions on panel p-1.

2. Randomly pick one of the pattern elements from p-1 and assign it to the identical position in p-2, p-3, and p-4.

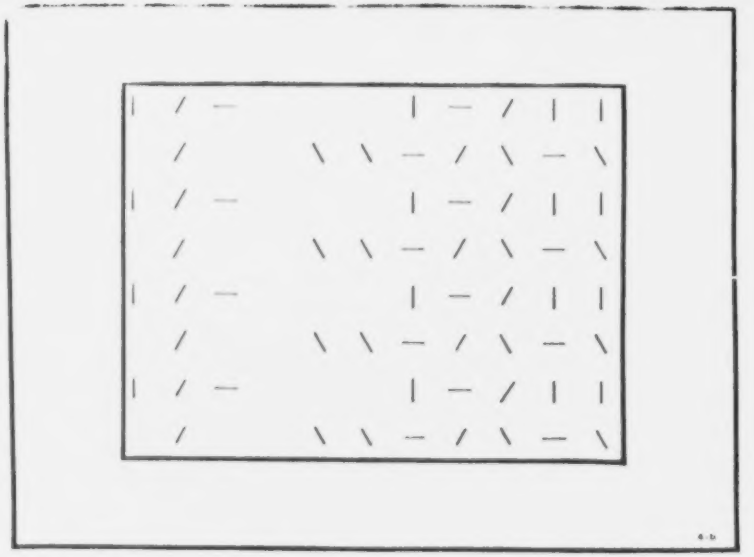
3. The remaining pattern element from p-1 is randomly reassigned to new positions in p-2, p-3, and p-4. Each of the reassignments to p-2, p-3, and p-4 should not duplicate any of the original positions from p-1 or any of the random assignments across p-2, p-3, and p-4.

4. On a sheet of gridded fade-out paper, randomly assign the pattern element (—) from E. 1., 2., and 3. to 4 positions in p-1. Randomly reassign 50% of the pattern elements in p-1 (4 positions) to p-2, p-3, and p-4 as described in E-3. The remaining elements should be assigned to identical positions in p-2, p-3, and p-4 as described in E. 2.

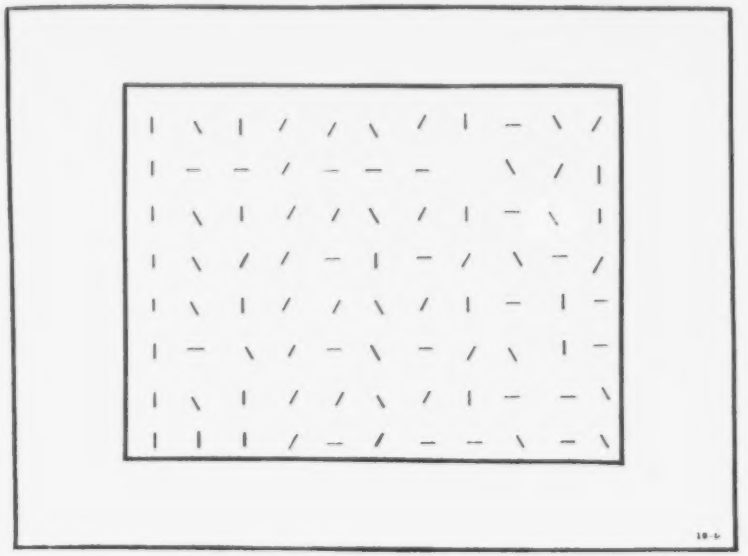
5. On another sheet of gridded fade-out paper, repeat E. 4. on 8 positions.
6. On a clean fade-out grid, repeat E. 1., 2., 3., 4., and 5. with 2 (— |) pattern elements. On another gridded fade-out sheet, repeat E. 1., 2., 3., 4., and 5. with 4 pattern elements.



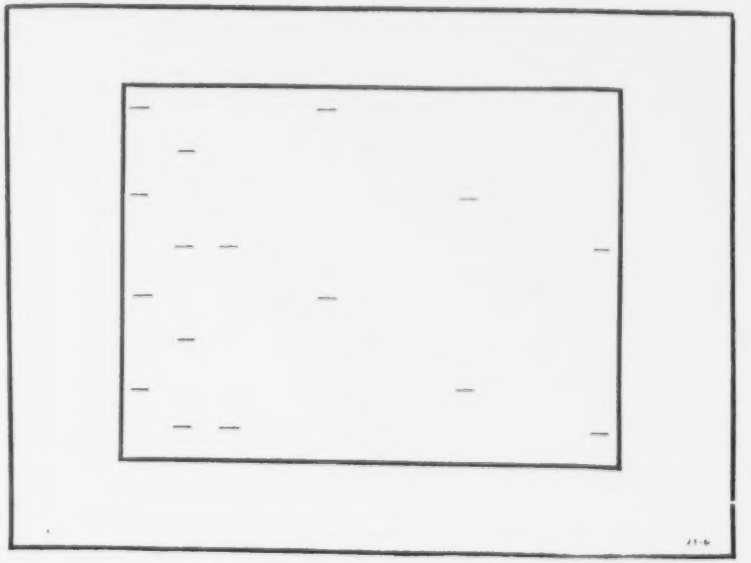
Low complexity and low redundancy



Medium complexity and high redundancy



High complexity and high redundancy



Low complexity and medium redundancy

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